Preliminary results of SO_2 measurements in SW Romania using UVGasCam cameras

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Outline

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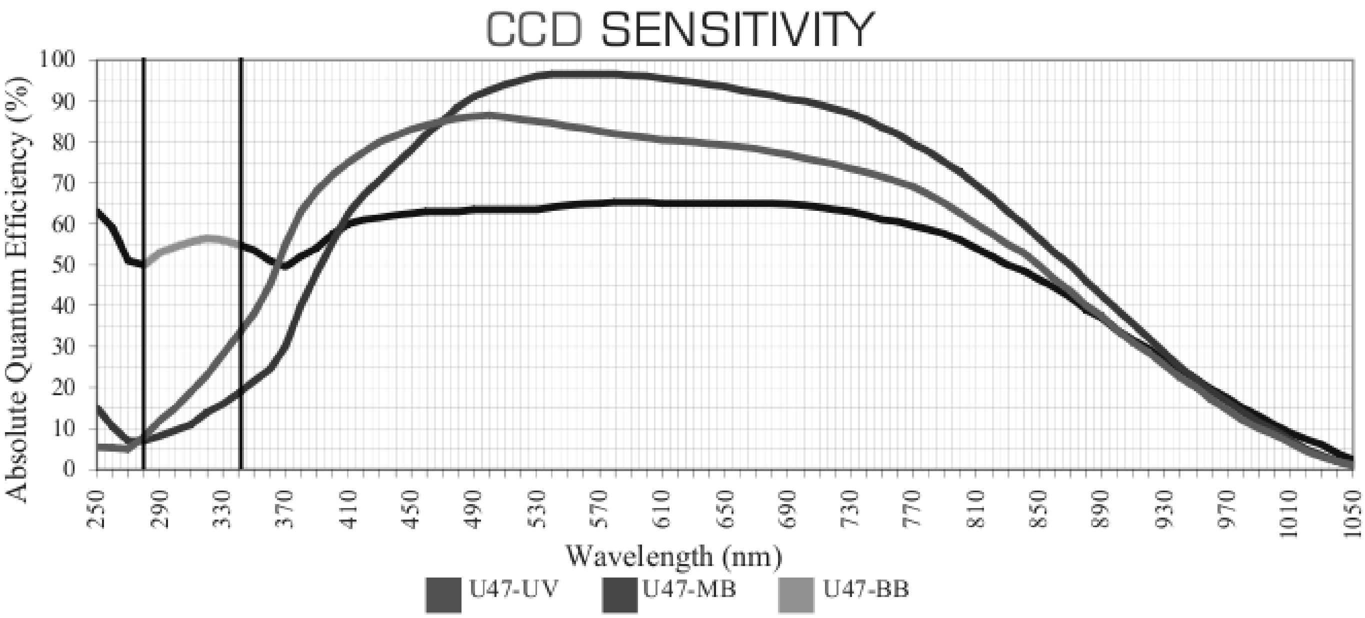
Motivation

- Environment
- Healthcare
- Risk assessment
- Climate change (better radiative transfer modeling)
- New Ideas

Campaign Description

Instrumentation

Description of the UVGasCam



- High quantum efficiency
- Cooled CCD system
- Filter wheel
- Fully automated

Instrumentation

Other available instruments

Instrumentation

Other available instruments

- Comparison needed for validation
- Fully automated robust system
- Easy as taking an ordinary picture
- But also has limitations

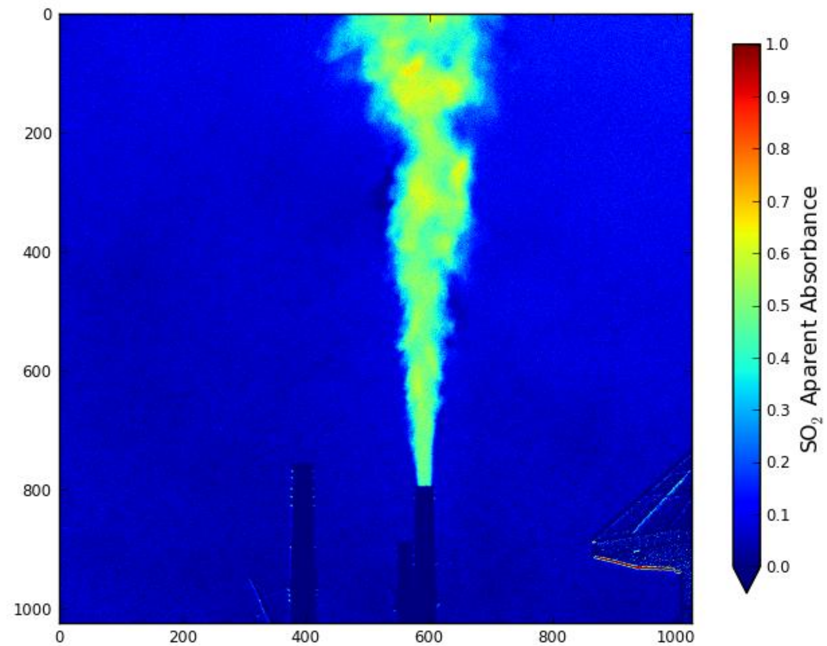
Results

Retrieval description

$$AA(i,j) = -log\left[\frac{\left(I_{A_s}(i,j) - I_{A_d}(i,j)\right)/\left(I_{A_b}(i,j) - I_{A_d}(i,j)\right)}{\left(I_{B_s}(i,j) - I_{B_d}(i,j)\right)/\left(I_{B_b}(i,j) - I_{B_d}(i,j)\right)}\right] + offset(i,j)$$

Derived from Beer-Lambert Law (for filter A) and normalized to filter B (apparent absorption)

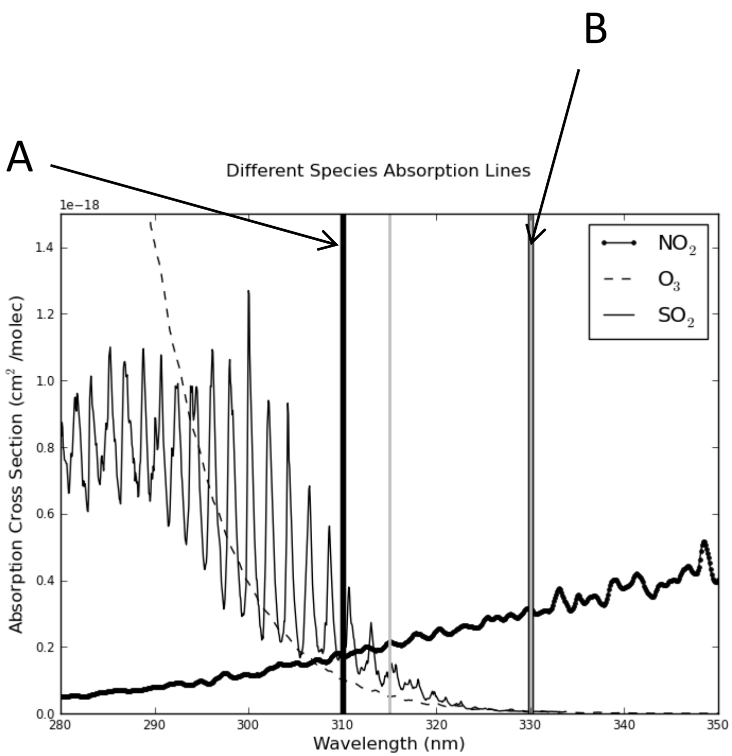
- I_A and I_B – intensity from filter A and respectively filter B
- s, d, b – scene, dark and background measurements respectively

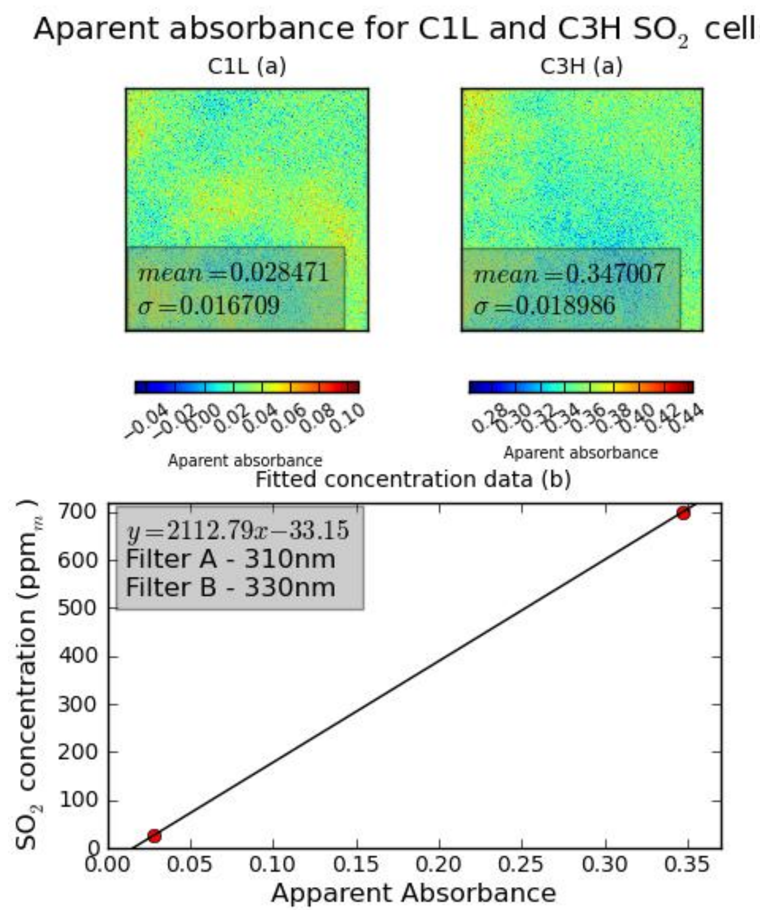


Intermediate product (AA)

Results

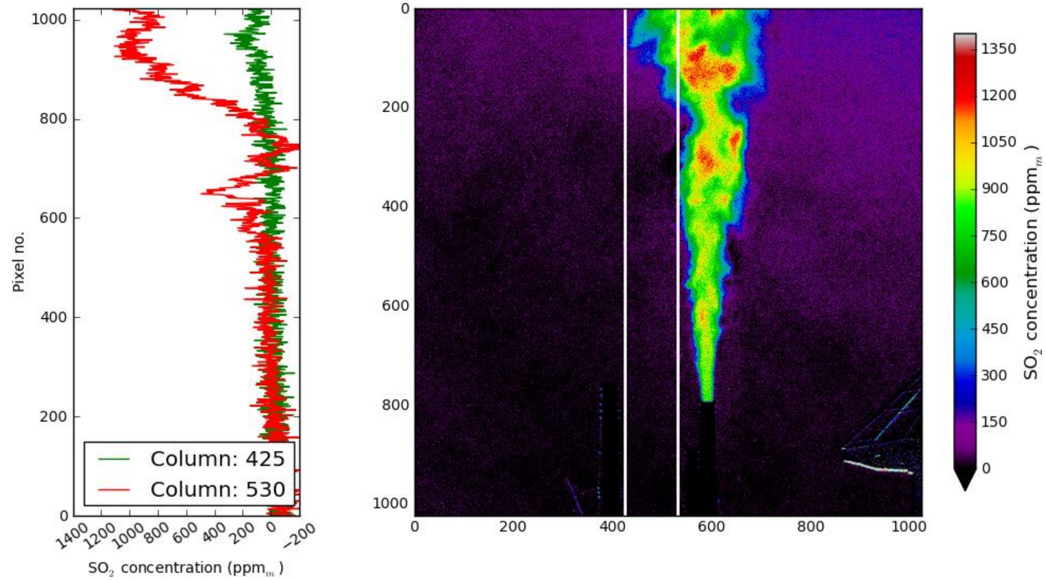
Retrieval description

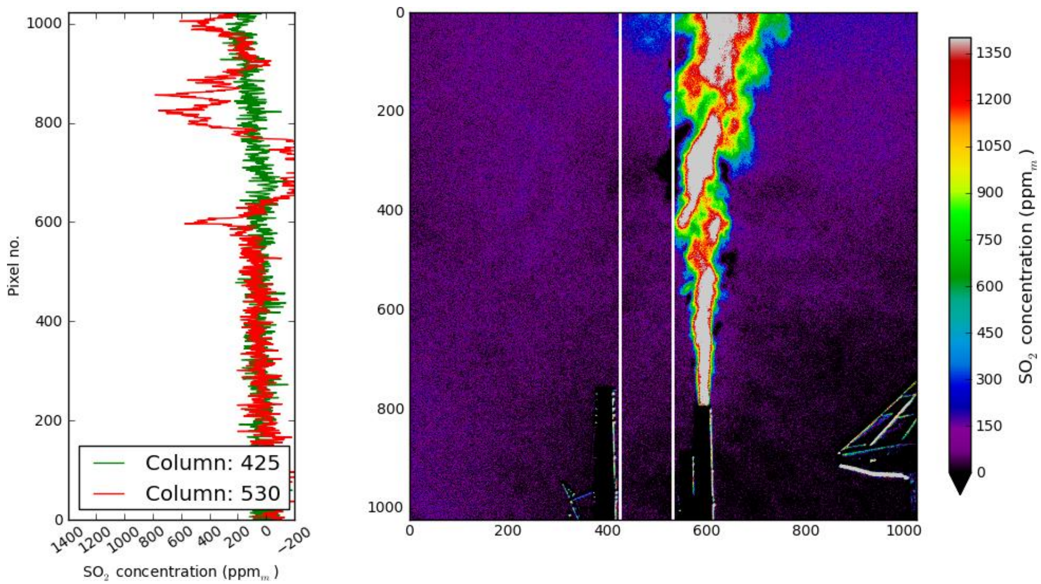




Results

Concentration “images”





Theory

spectroscopic instrument

- Intensity of a pixel in absence of SO_2 → $I_{0,A}(\lambda) = I_S(\lambda) \cdot T_A(\lambda) \cdot Q(\lambda)$
- Intensity if SO_2 is present in the optical path → $I_A(\lambda) = I_{0,A}(\lambda) \cdot \exp\big(-\sigma(\lambda) \cdot S(\lambda)\big)$
- Column density → $S(\lambda) = \int_L c(x)dx$
- Optical depth at specific wavelength → $\tau(\lambda) = -\ln\left(\frac{I_A(\lambda)}{I_{0,A}(\lambda)}\right) = \sigma(\lambda) \cdot S(\lambda)$

A spectroscopic instrument measures this quantity ($\tau(\lambda)$)

Theory

The UV camera way

$$I_{A_b} = \int_\lambda I_{0,A}(\lambda)d\lambda \qquad I_{A_s} = \int_\lambda I_A(\lambda)d\lambda$$

$$\hat{\tau}_A(\lambda) = -\ln\left(\frac{I_{A_s}}{I_{A_b}}\right) = \ln I_{A_b} - \ln\left(\int_\lambda I_{0,A}(\lambda)\cdot\exp\left(-\sigma(\lambda)\cdot S(\lambda)\right)\mathrm{d}\lambda\right)$$

$$\hat{\tau}_A(\lambda) = -\ln\left(\frac{\int_\lambda I_S(\lambda)\cdot T_A(\lambda)\cdot Q(\lambda)\cdot\exp\left(-\sigma(\lambda)\cdot S(\lambda)\right)\mathrm{d}\lambda}{\int_\lambda I_S(\lambda)\cdot T_A(\lambda)\cdot Q(\lambda)\,\mathrm{d}\lambda}\right)$$

$$\hat{\tau}_A(\lambda) = -\ln\left(\frac{I_{A_b}\exp\left(-\sigma\cdot S\right)}{I_{A_b}}\right) = \sigma\cdot S = \tau$$

- Measured quantities
- Calculated quantities (weighted average optical depth)
  - cross section and column density of SO_2 dependent of wavelength
  - independent cross section and column density

Theory

Normalized optical depth (apparent absorbance)

Complex relationship between the measured weighted average optical depth and the SO_2 column density

↓

Empirical calibration (simplify), but the SO2 has to be the only parameter to influence light attenuation

In the UV part (250 – 320 nm), besides the SO_2 absorption, aerosol scattering and absorption processes are weakly dependent on wavelength.

↓

Second band pass filter used for quantifying the attenuation (or enhancement) not originating from SO_2 absorption.

Theory

Normalized optical depth (apparent absorbance)

$$\hat{\tau} = -\ln\left(\frac{I_{A_s}/I_{A_b}}{I_{B_s}/I_{B_b}}\right) = -\ln\left(I_{A_s}/I_{A_b}\right) + \ln\left(I_{B_s}/I_{B_b}\right) = \hat{\tau}_A - \hat{\tau}_B$$

Calibration

SO_2 Column concentration

Difficulties and limitations

Optical limitations

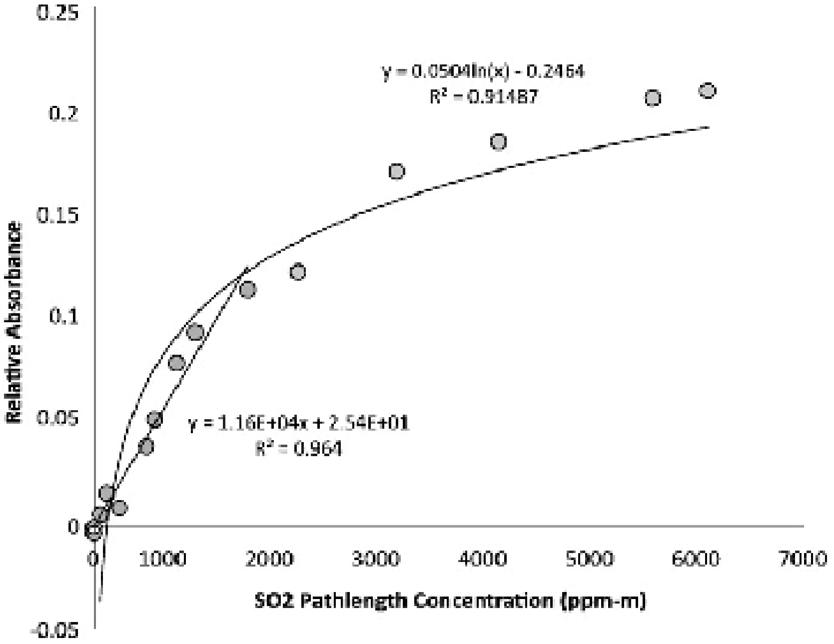
- Filter dependence on angle of incidence
- Vignette
- Calibration procedure demanding clear sky conditions
- Nonlinearity SO_2 column concentration on AA

Molecular interference

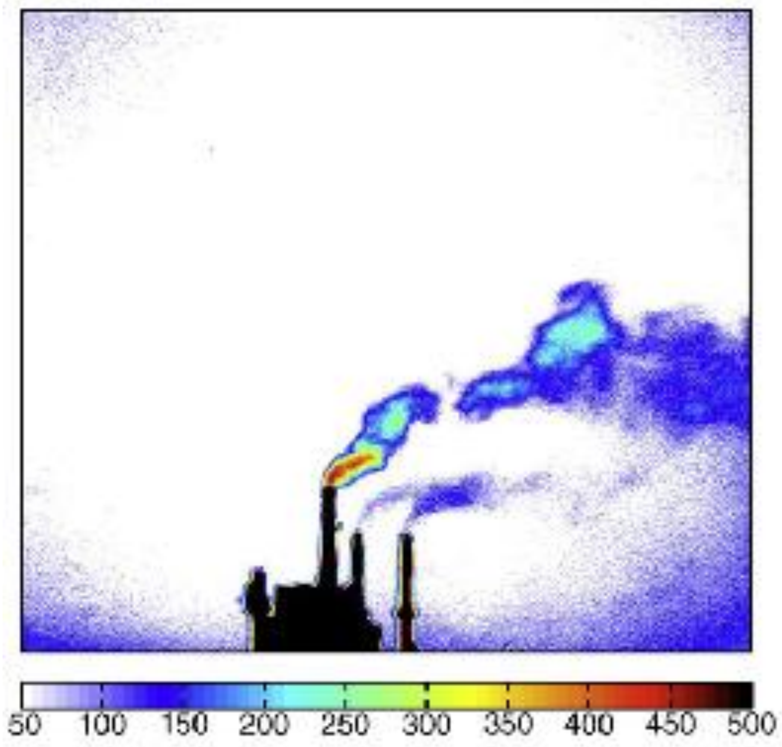
- Different species present in the light's path
- Presence of clouds / aerosols / water vapor – light scattered outside of the field of view, but also scattered into the field of view

Difficulties and limitations

SO_2 Concentration dependence on AA



Vignette



Concluding remarks

- Wide field of view in comparison with other instruments
- Flux measurement possibility
- Wind speed determination
- Highly sophisticated algorithms necessary for accurate measurements
- Promising instrument
- Future plans to make!

THANK YOU FOR YOUR ATTENTION